VESTA IN THE LIGHT OF DAWN, BUT WITHOUT HEDS? H. Y. McSween[1], D. W. Mittlefehldt[2], and the Dawn Science Team, [1]Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN 37996-1410, mcsween@utk.edu, [2]KR/Astromaterials Research Office, NASA/Johnson Space Center, Houston, TX 77058.

Introduction: The derivation of HEDs from Vesta is strongly supported by Dawn data [1], and these meteorites have made interpretations of Dawn spectra much more rigorous. Compared to the Moon, where samples became available *after* geologic mapping, the exploration of Vesta has been backwards. But what if HEDs had not been available or identified as vestan samples? What petrologic and geochemical predictions would have been possible using Dawn data, without the benefit of HEDs?

Compositional Mapping: VIR , FC, and GRaND compositional maps of Vesta [2,3,4] reveal that the regolith consists of regionally varying combinations of basalt and orthopyroxenite, based on comparisons with HEDs. But would these specific lithologies have been identified from VISNIR spectra indicating only Fe-bearing pyroxenes of varying composition, or from neutron absorption values or global Fe/O and Si/O ratios? And without the ability to analyze the mineralogy and chemistry of eucrite and diogenite end members, modeling regolith mixing and the petrogenesis of the igneous rocks would be qualitative at best. Assuming that samples had been extracted and launched from the 500 km diameter Rheasilvia basin (as inferred from observations of the Vestoids [5]), we probably would have predicted, based on petrologic reasoning, that crustal basalts or gabbros (eucrites) would be the most abundant lithologies, as observed. However, the high abundance of basaltic eucrites (63%) relative to cumulate (3%) and polymict (34%) eucrites would probably not be predicted. An estimate of regolith thickness ($\leq$1 km) [6] predicts that regolith breccias (howardites) would be less abundant, as observed.

Regolith Properties: Without the observation of CM clasts in howardites, it is arguable whether the unexpected discovery of H-rich [7] and OH-rich [8] regions on Vesta would have been interpretable in terms of exogenic carbonaceous chondrite containing hydrous minerals, although their occurrence as low-albedo regions might suggest a foreign component. The low amounts of impact melt in fresh craters seen in FC images [6] is consistent with models that imply limited melting due to low impact velocities, and would have correctly predicted limited amounts of impact melts in howardites. Recognizing the distinctive character of space weathering on Vesta [9] did not require HEDs, although the lack of agglutinates and nannophase iron in howardites provides confirmation of the spectral interpretation.

Magma Ocean: Dawn's observation that orthopyroxenite (if that lithology could have been identified) on Vesta has been excavated from the Rheasilvia basin (with a 30-45 km deep transient cavity, twice the estimated thickness of Vesta's crust [10]) would likely have led to the hypothesis of a global magma ocean, by analogy with the Moon. However, the complexity of vestan magma ocean models [11], involving a period of equilibrium crystallization followed by continuous extraction of residual melts into fractionating plutons at higher levels, is required by HED geochemistry. The homogeneity of oxygen isotopes in HEDs [12] is a predictable consequence of pervasive melting.

Mantle Composition: The lack of spectrally detectable olivine in Rheasilvia [13] might have led to a prediction of an olivine-free upper mantle. However, harzburgitic diogenites contain olivine [14], a discrepancy now reconciled by experiments showing the difficulty of spectrally detecting <25% olivine in the presence of orthopyroxene [15].

Core Size and Bulk Composition: The estimated core mass fraction of Vesta is ~18%, based on fitting of Dawn's determination of the gravitational moment J_2 [16]. We now know that this is in remarkable agreement with meteorite-based models of the HED parent body, with core mass fractions of 15-20% [17]. The core size is a critical constraint on Vesta's bulk composition, recently modeled as Na-depleted H chondrite with ~25% admixed CM chondrite [18]. This compositional model can yield eucrite-like melts, and has an Fe/Mn ratio, an oxygen isotopic composition, and a redox state like HEDs, but none of those constraints would be available without HEDs. Estimating this bulk composition is a necessary step in devising models for the thermal evolution [19] and magmatic differentiation [11] of Vesta.

Chronology: From the crater-saturated surface of Vesta and from crater-counting chronology of vestan units as >3.5 Ga [20], the ancient crystallization ages of HEDs [21] were predictable but not precisely quantifiable. Without $^{40}Ar/^{39}Ar$ measurements of HED breccias [22], the late bombardment by high-velocity impactors on Vesta [23] would not be recognized.

Conclusion: Our understanding of Vesta's geology and evolution is so inextricably linked to HEDs [24] that it is difficult to imagine a Dawn mission not informed by these samples. Vesta now joins the Moon and Mars as the only extraterrestrial bodies that have been geologically, petrologically, and geochemically characterized. Not coincidentally, samples are available for all three bodies.

References: [1] McSween H.Y. et al. (2013) *MAPS*, in press. [2] Ammannito E. et al. (2013) *MAPS*, in press. [3] Thangiam G.S. et al. (2013) *MAPS*, in press. [4] Prettyman T.H. et al. (2013) *MAPS*, in press. [5] Binzel R.P. and Xu S. (1993) *Science* 260, 186-191. [6] Jaumann R. et al. (2012) *Science* 336, 687-694. [7] Prettyman Y.H. et al. (2012) *Science* 338, 242-246-. [8] De Sanctis M.C. et al. (2012) *Ap.J. Lett.* 758, L36. [9] Pieters C.M. et al. (2012) Nature 491, 79-82. [10] McSween H.Y. et al. (2013) *JGR* 188, 335-346. [11] Mandler B. and Elkins-Tanton L (2013) *MAPS*, in press. [12] Greenwood R.C. et al. (2005) *Nature* 435, 916-918. [13] Ammannito E. et al. (2013) *Nature*, doi:10.1038/nature12665. [14] Beck A.W. and McSween H.Y. (2010) *MAPS* 45, 850-872. [15] Beck A.W. et al. (2013) *MAPS*, in press. [16] Russell C.T. et al. (2012) *Science* 336, 684-686. [17] Righter K. and Drake M.J. (1997) *MAPS* 32, 929-934. [18] Toplis M.J. et al. (2013) *MAPS*, in press. [19] Formissano M. et al. (2013) *MAPS*, in press. [20] Marchi S. et al. (2012) *Science* 336, 690-694. [21] McSween et al. (2011) *Space Sci. Rev.* 163, 141-174. [22] Bogard D.D. (2011) *Cheme de Erde* 71, 201-226. [23] Marchi S. et al. (2013) *Nature Geosci.* 6, 303-307. [24] Keil K. (2002) *Asteroids III*, 573-584.